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What is Hazardous? What is Safe?

by John W. Healy*

The definition of an acceptable risk involves many facets most of which are outside the control of the decision maker, but they must be recognized if a proper definition is to be made. Six of the principal factors are stated and discussed. (1) nothing is absolutely safe; (2) each individual or group of individuals has his own standards by which he judges risk; (3) perceptions of risk vary with the conditions at any one time in history; (4) there must be a compensatory benefit for taking any risk; (5) societal perception of a risk may be different from the actual risk; and (6) safety is only one of the many factors that must be considered in the design of a product or service.

The question of what is hazardous and what is safe may appear to be anomalous to some, because it is superficially apparent that an item that is hazardous is not safe and vice versa. However, this is one of the more important and controversial questions in the United States today. Decisions are being made, on some matters, that could lead to potential risk to members of the population. Conversely, decisions are also being made to ban some product or process because the risks are too great. How are such decisions made? What is a rational basis for them? I do not propose to provide answers to these questions because the problem is extremely complex and, in fact, is probably insoluble by the normal scientific or technical ways of viewing reality. Instead, I will present some thoughts that may be of use in better understanding the problem and in implementing approaches to its solution.

This question is particularly appropriate to the subject of this symposium because we must consider what we mean by hazardous before we can decide on treatment or disposal of "hazardous" solid waste. An error could lead to a waste of resources if a relatively innocuous material is treated as hazardous; alternatively, it could result in harm to people or the environment by allowing inadequate treatment and disposal of a harmful material.

There are several principles that I feel to be of importance in assessing the rationale for present practice and that must be included in the thinking of those who make decisions that are primarily of a societal nature: (1) nothing is absolutely safe; (2) each individual or group of individuals has his own standards by which he judges risks; (3) perceptions of risk vary with the conditions at any one time in history; (4) there must be a compensatory benefit for taking any risk; (5) societal perception of a risk may be different from the actual risk; (6) safety is only one of the many factors that must be considered in the design of a product or service.

It will be noted at the outset that the major bases for these principles result from people and the way that they think and act rather than from the detailed technical analysis and knowledge of the scientist. This, perhaps, explains the frustration of the scientist or the engineer who "proves" that a risk is low and acceptable by a detailed analysis only to find that he cannot gain acceptance by the public. In the following, we will discuss some observations on each of these principles.

The first, that nothing is absolutely safe, is a truism that derives from the fact that man is mortal, and, in addition to the effects of disease and aging, can be killed or injured by a number of activities in which he engages. This is well illustrated by the vital statistics of this, or any other country, which show illness and death in all age categories. While we regard this principle as a truism, we must also recognize that people do not like to have either themselves or their families and friends harmed, so that any risk from our activities must be held to a level low enough to meet the expectations of the public. This is defined in many quarters as an "acceptable" risk. It is not, however, appropriate for the public to ask for a risk of absolutely zero while at the same time obtaining the benefits of a product

* Los Alamos Scientific Laboratory, P. O. Box 1663, Los Alamos, New Mexico 87545.

or service. This is basically barred by our first principle. Thus, the first hurdle in defining a safe product is in assessing the level of risk that may occur and the reaction of the public to this risk as well as to the value that they may place on the benefits brought by the action.

The second principle, that people differ in the way that they judge risks, has been codified in decision theory which uses this principle as the basis for further derivations. In this theory it is noted that individuals have different ways of looking at risk and that the attitude of an individual can be represented by utility curves or curves that plot the willingness of an individual to risk various outcomes for which a probability of both losing and winning are present. These curves are as widely different for different individuals in their willingness to take risk or their aversion to risk as are the other characteristics of individuals. The corresponding curve for that nebulous entity that we call society or the public is the total or weighted average of each of the individuals in the society. I say weighted average because there are people who are more influential in arriving at the societal curve than others. For example, there are now very vocal groups who influence the public perception of risk. Interestingly enough, these people frequently concentrate on one source of risk and demonstrate great risk aversion to this source, meanwhile ignoring much greater risks that could be reduced at a much lower cost than the one of concern. Thus, individuals and groups may have different utility curves for different sources of risk, resulting in even greater overall social disparity in the perception. However, no one has ever stated that human affairs are conducted by logic alone, nor would I necessarily recommend that logic be the major touchstone.

The third principle, that perceptions of risk vary with the conditions at the time, has been discussed by Lowrance (*1*). Essentially it means that the degree of risk aversion depends upon the risks existing at the time as well as upon the current amenities of life. To illustrate the principle, let us consider a hypothetical situation in which the only way that an individual could be harmed would be by one specific type of activity. Otherwise the life span would be, for all practical purposes, infinite. In this case, we can predict that most people would have a high degree of aversion to this particular risk. On a less hypothetical basis, primitive man lived with serious risks of all kinds: disease, animals, and even other men. Death and injury were common experiences and were accepted with some degree of fatalism because control of such risks required the development of technology and institutions far beyond his comprehension. Within living memory, diseases such as diphtheria, typhoid fever, and pneumonia took a fearsome toll. These all affected the way that people regarded risks and their consequences.

From this, one can conclude that the control of one risk will result in increased importance of another in the public mind. Thus we foresee a continually changing spectrum of risks with a new one, usually of lesser intensity, replacing each one that is controlled. However, the fact of lesser intensity does not mean that public concern is lessened because the next risk becomes important in the overall spectrum of risks existing at the time and the expectations of the public have been increased by the elimination of the earlier risk. This means that as our ability to control risks increases, we can expect to be held to even higher standards in all phases of our activities. This may be a discouraging prospect for many technologists who feel that current desires in many areas are already close to unattainable, but it is a trend that must be taken into account in planning for the future.

The fourth principle, that a benefit should accrue for taking a risk, can be observed in practice in the actions of people. For example, individuals do take high-risk jobs because the pay is worth the risk to them and, presumably, because they enjoy the prestige associated with the work. In leisure activities, some people gain the benefit of enjoyment from mountain climbing, skiing, and swimming although the record clearly shows that people engaged in these activities are hurt and killed every year. Obviously these people see benefit in such activities or they would not expose themselves to the added risk. Perhaps the classic example is the use of the automobile in our society. In addition to the injuries and deaths, the degradation of the air quality over our cities poses a significant risk. Yet the benefits of convenient and personalized transportation appear to outweigh, in the minds of most people, these very obvious risks.

The above are illustrations of what have been termed "voluntary" risks. In this class of risk, the added risk is accepted voluntarily and the consequences are, for the most part, to the individual participating. This is not completely true, since there are risks to others such as pedestrians, the team that must rescue the downed flier or fallen mountain climber, or the public from the air degraded by the automobile. However, these are rarely considered by the individual deciding to participate. Starr (*2*) has noted that we appear to accept a voluntary risk that is much higher than one that is imposed upon us by others.

An involuntary risk is one over which we have little or no direct control. Such manifestations of

nature as hurricanes, tornados, or lightning bolts are frequently quoted as examples. Others are the effluents from factories or other effects of our technology. In theory, a person living in an area where such risks occur can avoid them by moving to an area where they do not occur or are less prevalent. However, in moving, one may simply substitute one type of risk for another. In addition, we are frequently so trapped by the forces of our society, such as lack of means to move, or the necessity of working at a job in one particular area, that such a method of avoidance is actually impossible. It is also of interest that such societal "traps" can result in a voluntary risk becoming an involuntary risk. For example, the automobile, frequently quoted as a prime example of the voluntary risk, has so shaped our choice of places of living and our transportation system that in many cases we must use it, and take the consequent risk, to get to our jobs or even to the stores for food or clothing.

The potential exposure to risks as a result of our technology is real and has been of concern to many people. In recent years, the practice of banning products that show no benefit to the user, even if the risks are low, is a prime application of our fourth principle. The exposure to effluents from the industrial activity of the country is frequently quoted as an involuntary risk and as an injust imposition of risk on those people exposed with the benefits accruing to the few—presumably those who make money out of the enterprise. I would suggest, however, that in our closely interconnected society, it is impossible to completely divorce oneself from his neighbor and his neighbor's activities. We are all interdependent for our food, clothing, energy, and even entertainment. How many people would survive if this enormous network were to disappear and we were left to our own resources to furnish the necessities of life? The answer, while not quantitative, is clear—very few! If you don't believe it, try raising enough fruits, vegetables and animals to feed yourself and your family in a typical city dwelling! Thus, rather than taking a narrow view that such activities impose an involuntary risk to the many while the few get the benefits, we must consider the benefits from the various activities to be to us as members of society and weigh the risks against the benefits to us in this role. Remember that our activities also impose a risk on others. The important question is not the imposition of risk at low levels, but rather, whether the product or service furnished by this activity produces benefits that outweigh the risk.

I cannot leave this principle without a few words about the cost-benefit analyses currently so popular in attempting to arrive at a decision. Such studies are useful for broadening the perspectives and knowledge of the individual doing the study. They are not without some danger, however. It is a popular belief that scientists are intimately familiar with all details of the potential impacts of a given technology. However, when we come to the point, we usually find that the situation is so complex that it is impossible to describe the impacts fully, and many assumptions are necessary to arrive at the final answer. Thus, two people can use the same basic information and arrive at two different balances depending upon their viewpoints. The tendency to "quantify the unquantifiable" so that the decision drops into the decision-maker's lap without the agony of preparing oneself and taking the necessary action is hard to resist. It is for these reasons that I feel that such studies should be used primarily as inputs to a decision made by knowledgeable and experienced people with the freedom to disagree with the conclusions of the analysis if their judgement tells them that the conclusions are wrong. I would also recommend that decisions should, whenever possible, be made only after a detailed and documented review of all the facts that are available. This not only assures that the facts have been considered, but it also allows others to understand the basis for the decision so that future changes can take the detailed basis into account.

The fifth principle, that the perception of a risk may be different from the actual risk, is one that frequently results in frustration for those who are engaged in an endeavor which they are convinced is safe and useful but which results in opposition from the public, or more correctly, from some segment of the public. There are two types of people who are involved in this principle. The first consists of those who use the risk argument to oppose an action that they disapprove of for other reasons and who see the risk argument as one that will persuade other people to oppose the action also. For example, there are those who feel that technology has gone too far and that we should all resort to a "simpler existence." These people are therefore obliged to fight any new advance with the presumed hope that failure of this proposal will, at least, prevent further encroachment on their desires and may be a first step toward retrenchment in other areas. It is unfortunate that this group of people is not really willing to discuss their real desires because it is possible that there could be some agreement with their thoughts. However, discussions on risk and benefits are useless for these people because their decision was made on other grounds.

The second type of person is one who is sincerely concerned about the potential risks and is unwilling to trust those in authority (either in government or

in the organization advocating the technology) to take proper precautions. As an aside, it is my opinion that we have become all too willing to mistrust the motives of those who advocate some action and who are the ones with the knowledge to take appropriate action. It is often proposed that the objections of this group of people can be overcome by a "public relations compaign." However, such campaigns too often become sales gimmicks designed to tout the safety and validity of the technology rather than a sincere effort to provide the people with facts and a candid discussion of the problems. It is my opinion that this problem can only be overcome by conducting our business in such a way that the decisions being made are in the good interests of both the public and the industry. While short-range gains may be made by taking short cuts on a self-interest basis, the long-range loss in confidence, not only of those taking the short cut, but also in the entire establishment, will more than nullify these short-term gains. It is noted that the requirements for open meetings in the government were designed to assure that decisions were made in an open manner to protect the interests of all involved. While the motive, and frequently the execution, is praiseworthy, there are some difficulties because any attempt to explore the issues involved fully can raise questions that are not resolved; when these questions are sensationalized, added prejudice against the project can result.

The last principle essentially states that the safety of an endeavor cannot be isolated from other factors such as workability, resource cost, economics, and benefits. Safety or the degree of freedom from risk is as much an attribute of the endeavor as any of its other features and frequently results from trade-offs with these other attributes. In the initial stages of any project, decisions must be made as to whether adequate safety can be obtained at a cost that will enable the benefits to the user to outweigh this cost. When this balance cannot be achieved the action should not be taken. For projects where the risks are within bounds, safety becomes one of the specific design questions. In past years, the tradeoffs between workability, costs, and other features with safety were made by engineers with their main guidance being feedback from the market place (which, in this case, includes legal suits for nonperformance or accidents).

In recent years, the regulatory process has intervened to prescribe mandatory actions to obtain safety. This serves to assure that some interest other than that of the advocate is involved in the decisions. However, it is far from clear that the regulators can provide proper trade-offs because their chartered interest is only in the safety of low risk aspects of the project. Since they operate in a political atmosphere, their natural tendency is to keep risks as low as possible without regard to these other factors. Obviously if an accident occurs or a risk develops, they are called to account. Of course, in a political arena some counterpressures can be brought to bear, but these are frequently not effective. As a result, we cannot be certain that optimal balances between safety and costs or resource allocations are being achieved.

Now we must ask ourselves what these principles mean to our disposal of hazardous waste. Such disposal is an activity that must be carried out not only by industry but also by government at all levels. The costs will be borne by the public, indirectly in higher costs of products or unavailability of products or services from industry if the disposal costs are too high, or directly in taxes if a government operation is involved. It is, therefore, of importance to each citizen to see that optimal balances are struck between the requirements to reduce the hazard and the risks that are finally permitted. While no formula has been devised or proposed to apply these principles to decision making, some awareness of them should enable those responsible, both in government and in industry, better to consider and take action on the legitimate interests of the public even if such interests are not always clearly articulated. This poses many problems in view of the wide differences in viewpoints toward individual sources of risk, and it is not clear as to how these viewpoints should be balanced against those of the expert. Suffice it to say that we are apparently rewriting the Golden Rule to: "Do not unto me as you would have me do unto you; rather do unto me as you think that I would be done unto."

I would be remiss in a symposium on hazardous wastes if I did not mention the question of risk to future generations. This question has been raised repeatedly in the problems of nuclear waste disposal and undoubtedly will be raised for other hazardous wastes (particularly when they are labeled as "hazardous"). It is a perplexing question, particularly because of our inconsistency in our attitudes toward this question and others that affect the future. For example, we are depleting the resources of the earth in minerals as well as energy. The growing deserts in may parts of the world illustrate our disregard for the most important resource of all, our soils. At the same time, we tend to resist the introduction of new technologies that could, to some degree, alleviate some of these future problems. The basic questions that we must answer are how much we should spend and what activities we must forego because of a potential risk in the far distant future. At the same time we must consider

what technologies we must develop, even at some risk to ourselves, to assure that there will be people with a civilization far enough advanced to appreciate the freedom from risk. While it is tempting for the people of this country to assume that the United States has resources great enough to accomplish any task that it desires with no sacrifice to them, recent events indicate that there are limitations that must be respected if we are to continue as a great nation. I would suggest that a national policy on this question of future risk is needed so that the engineers who must design the facilities have guidance as to the goals and the need to justify bases for the future risk for each facility can be eliminated. Hopefully, such a policy would be developed following thorough study and discussion with mature reflection on all viewpoints.

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